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Vanderhoff

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(54) **SOFT DECISION MAKING PROCESSES FOR ANALYZING IMAGES**

(75) Inventor: **Earl W. Vanderhoff**, Cranston, RI (US)

(73) Assignee: **Verizon Patent and Licensing Inc.**, Basking Ridge, NJ (US)

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G06K 9/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G06K 9/00744*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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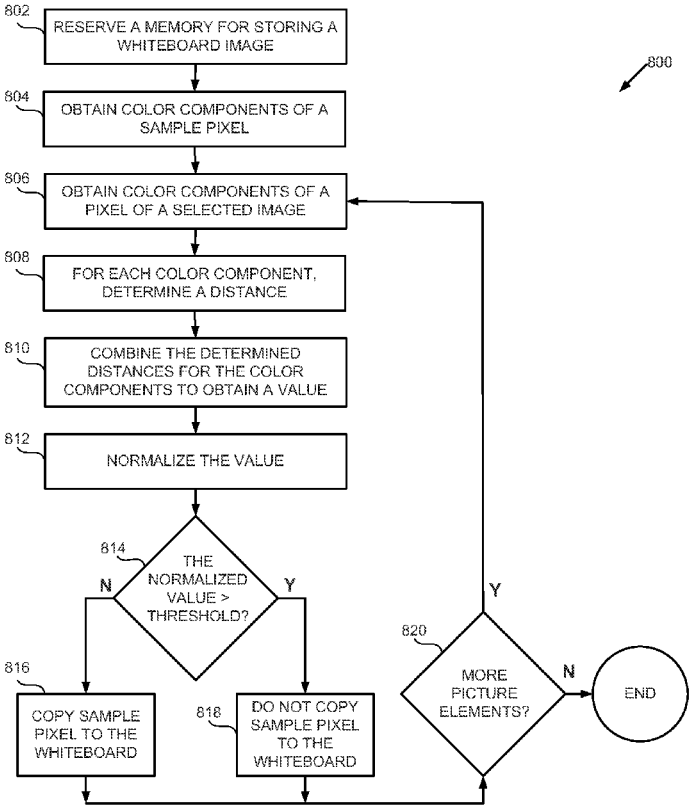
Primary Examiner — Eueng-Nan Yeh

(57) **ABSTRACT**

A device may calculate a normalized value for each of a number of pixels in a frame of a video stream, by obtaining a first color from one of the pixels and a second color, by obtaining color components of the first color and the second color, by, for each of the color components, determining a distance between the first color and the second color, and by adding the distances of the color components to obtain the normalized value. In addition, the device may compute an accumulation of the normalized values, compare the accumulation to a threshold to determine whether a first image that includes the pixels matches a second image that includes the second color, and display a result of determining whether the first image matches the second image via a graphical user interface (GUI).

20 Claims, 11 Drawing Sheets



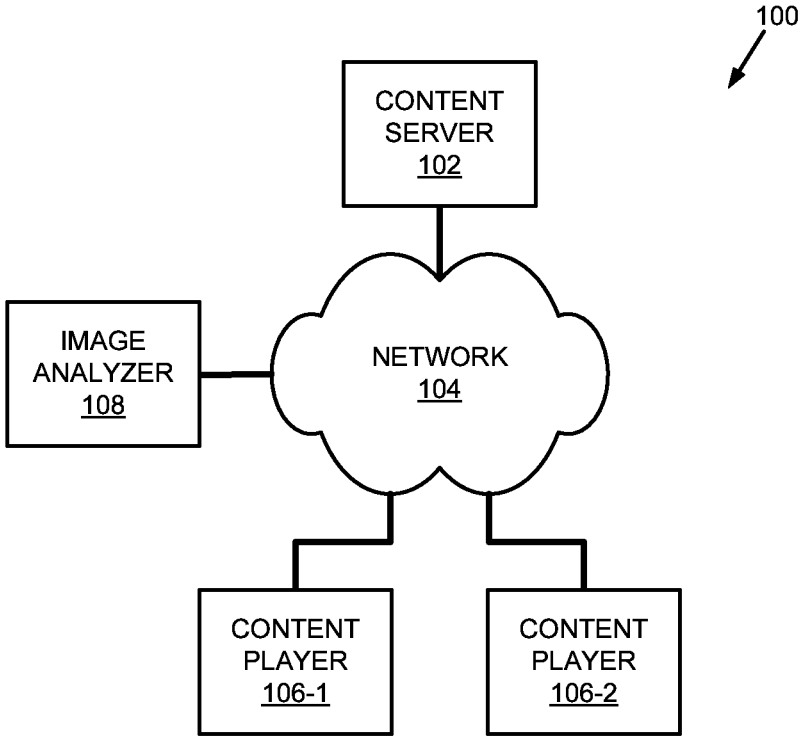

100
CONTENT SERVER 102
IMAGE ANALYZER 108
NETWORK 104
CONTENT PLAYER 106-1
CONTENT PLAYER 106-2

Fig. 1

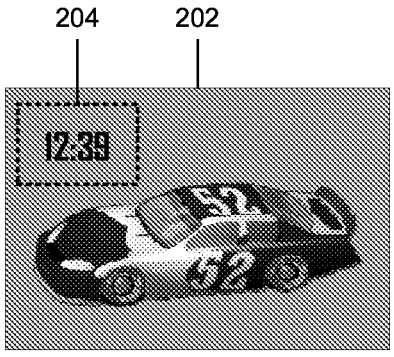

204
202
12:39

Fig. 2A

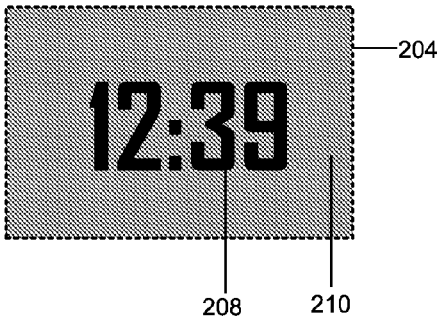


Fig. 2B

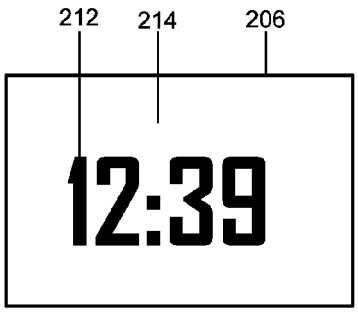


Fig. 2C

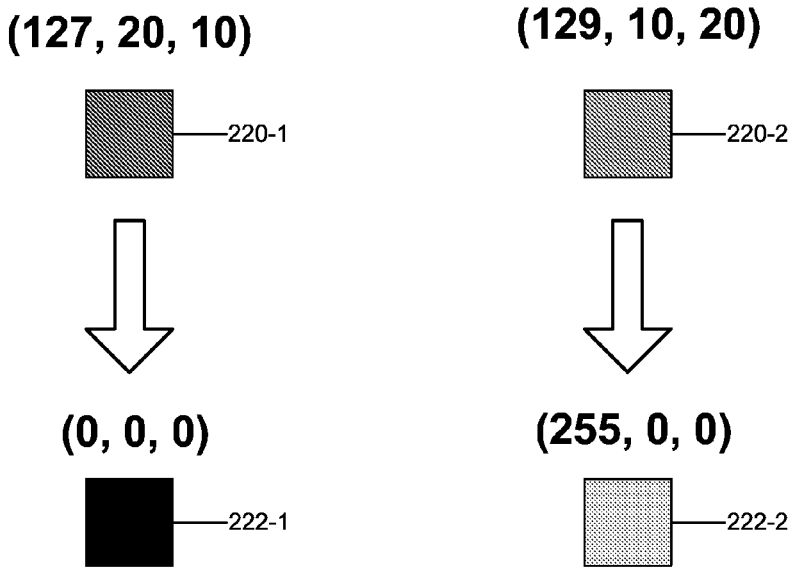


Fig. 2D

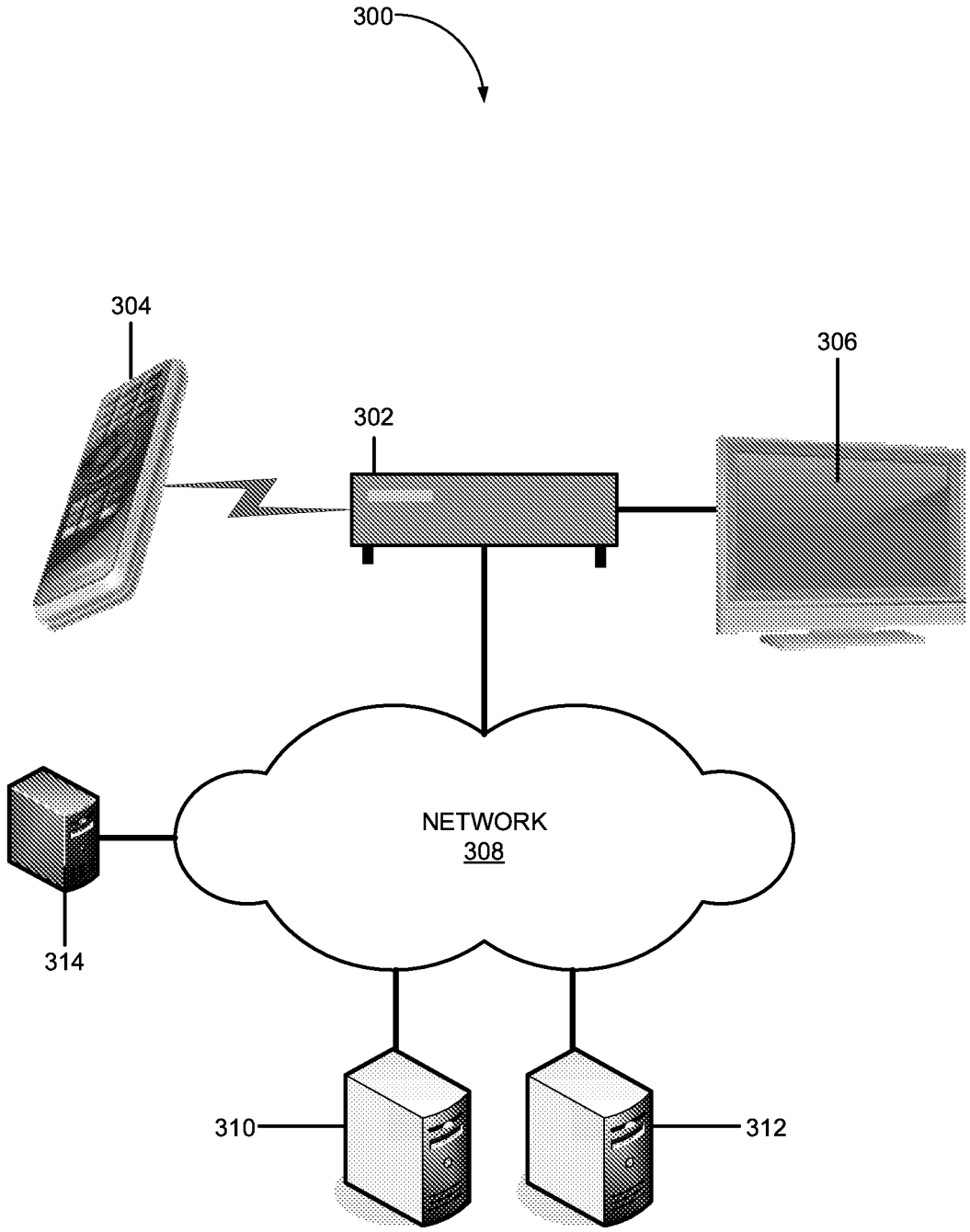


Fig. 3

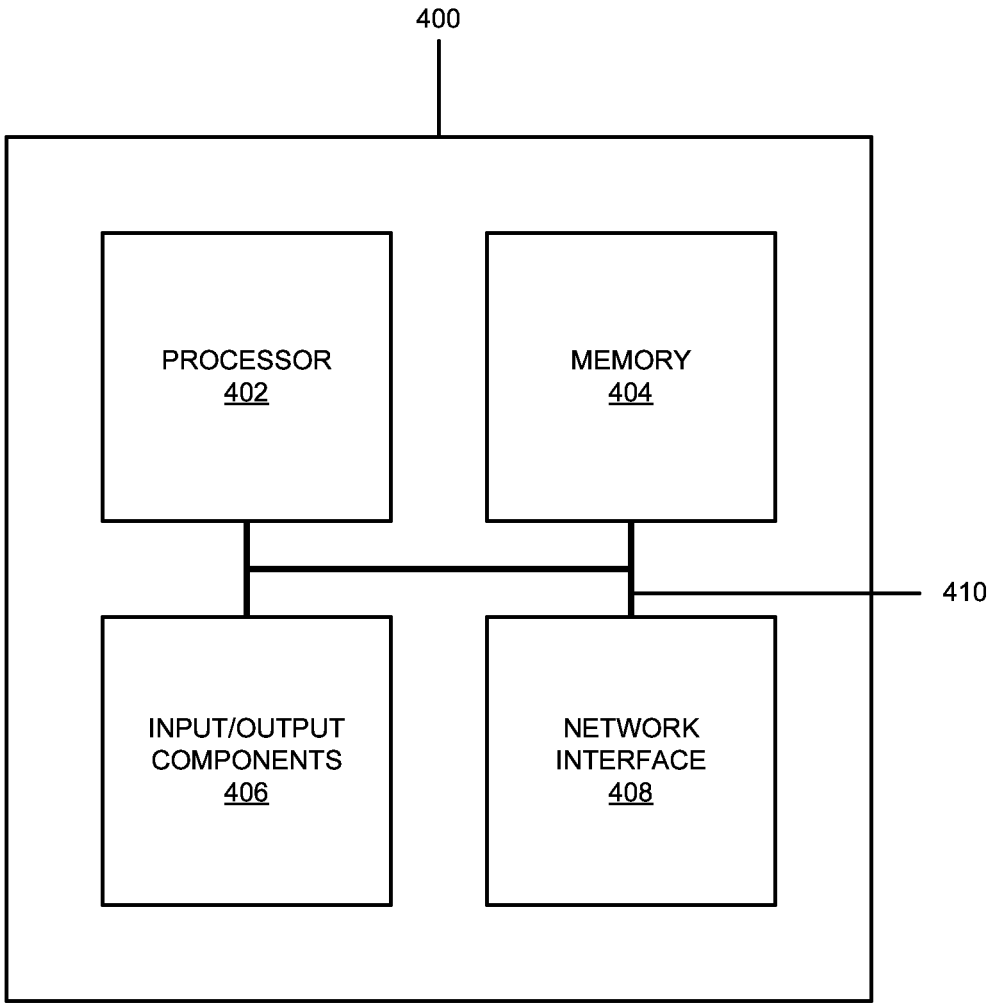

400
PROCESSOR
402
MEMORY
404
410
INPUT/OUTPUT
COMPONENTS
406
NETWORK
INTERFACE
408

Fig. 4

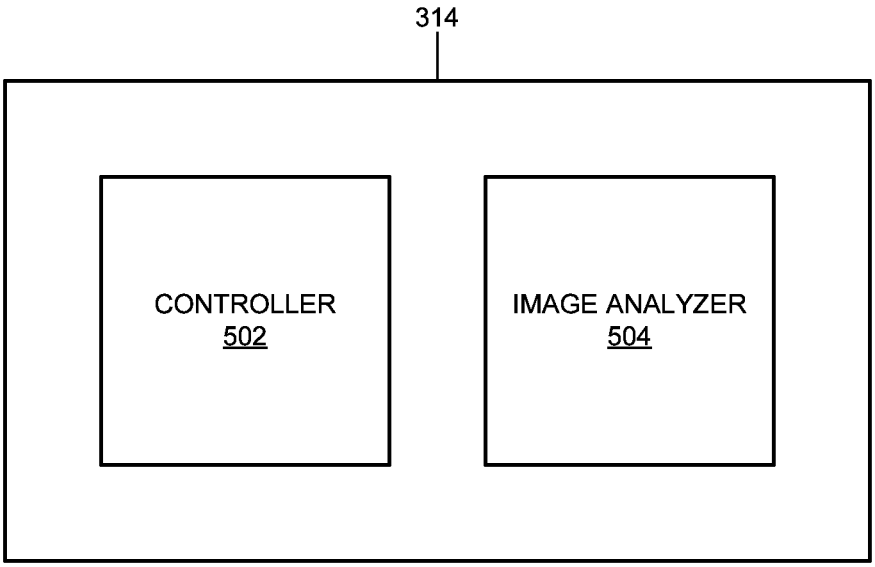


Fig. 5

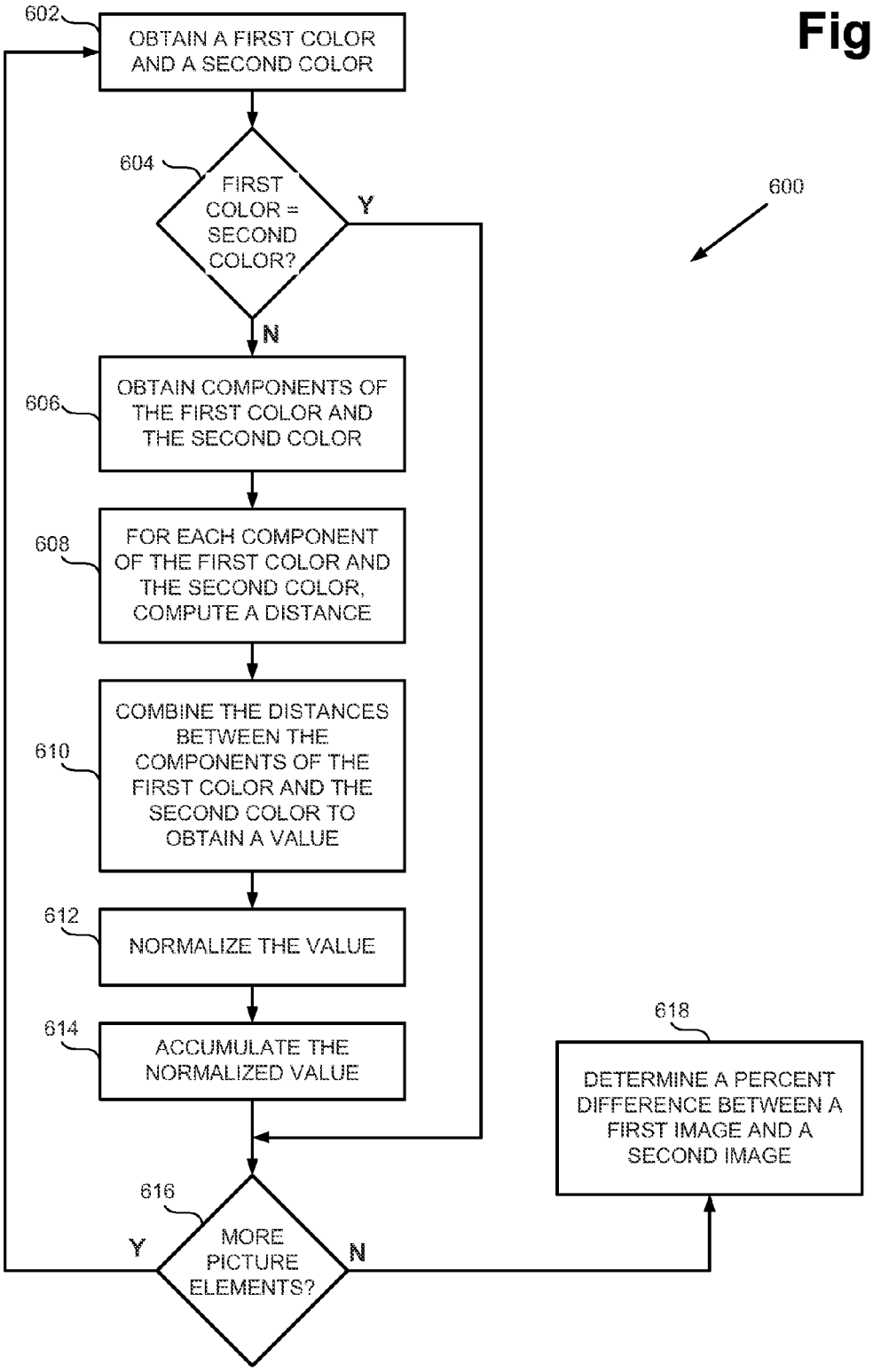

602
OBTAIN A FIRST COLOR AND A SECOND COLOR
604
FIRST COLOR = SECOND COLOR?
Y
N
600
606
OBTAIN COMPONENTS OF THE FIRST COLOR AND THE SECOND COLOR
608
FOR EACH COMPONENT OF THE FIRST COLOR AND THE SECOND COLOR, COMPUTE A DISTANCE
610
COMBINE THE DISTANCES BETWEEN THE COMPONENTS OF THE FIRST COLOR AND THE SECOND COLOR TO OBTAIN A VALUE
612
NORMALIZE THE VALUE
614
ACCUMULATE THE NORMALIZED VALUE
616
MORE PICTURE ELEMENTS?
Y
N
618
DETERMINE A PERCENT DIFFERENCE BETWEEN A FIRST IMAGE AND A SECOND IMAGE

Fig. 6A

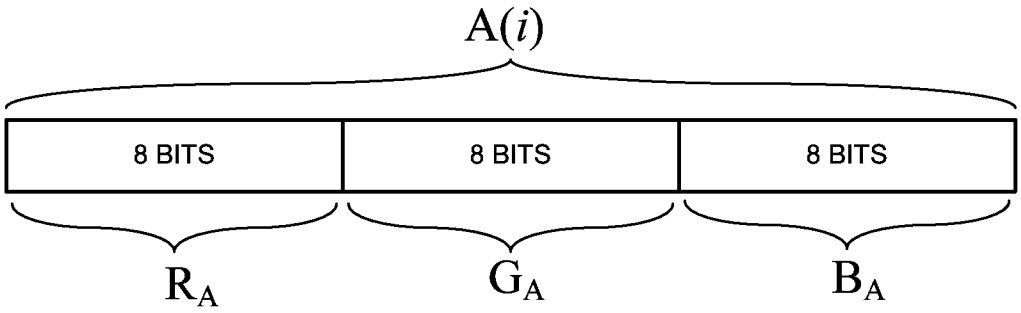

A(i)
8 BITS
8 BITS
8 BITS
R_A
G_A
B_A

Fig. 6B

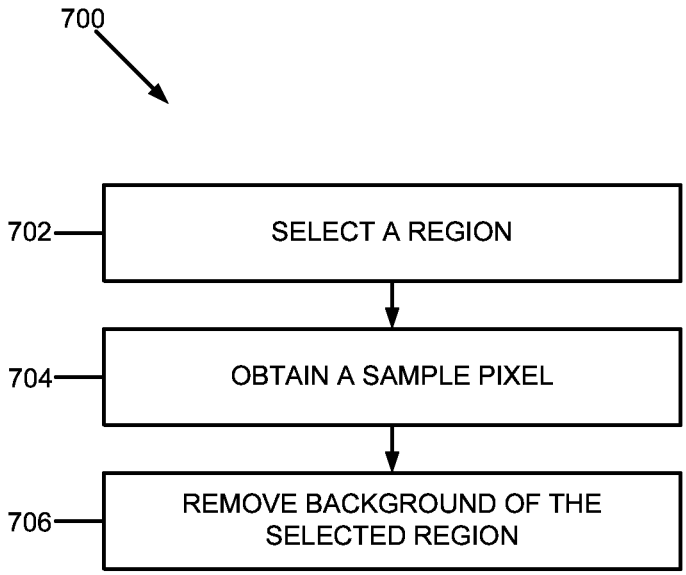

700
702
SELECT A REGION
704
OBTAIN A SAMPLE PIXEL
706
REMOVE BACKGROUND OF THE SELECTED REGION

Fig. 7

Fig. 8

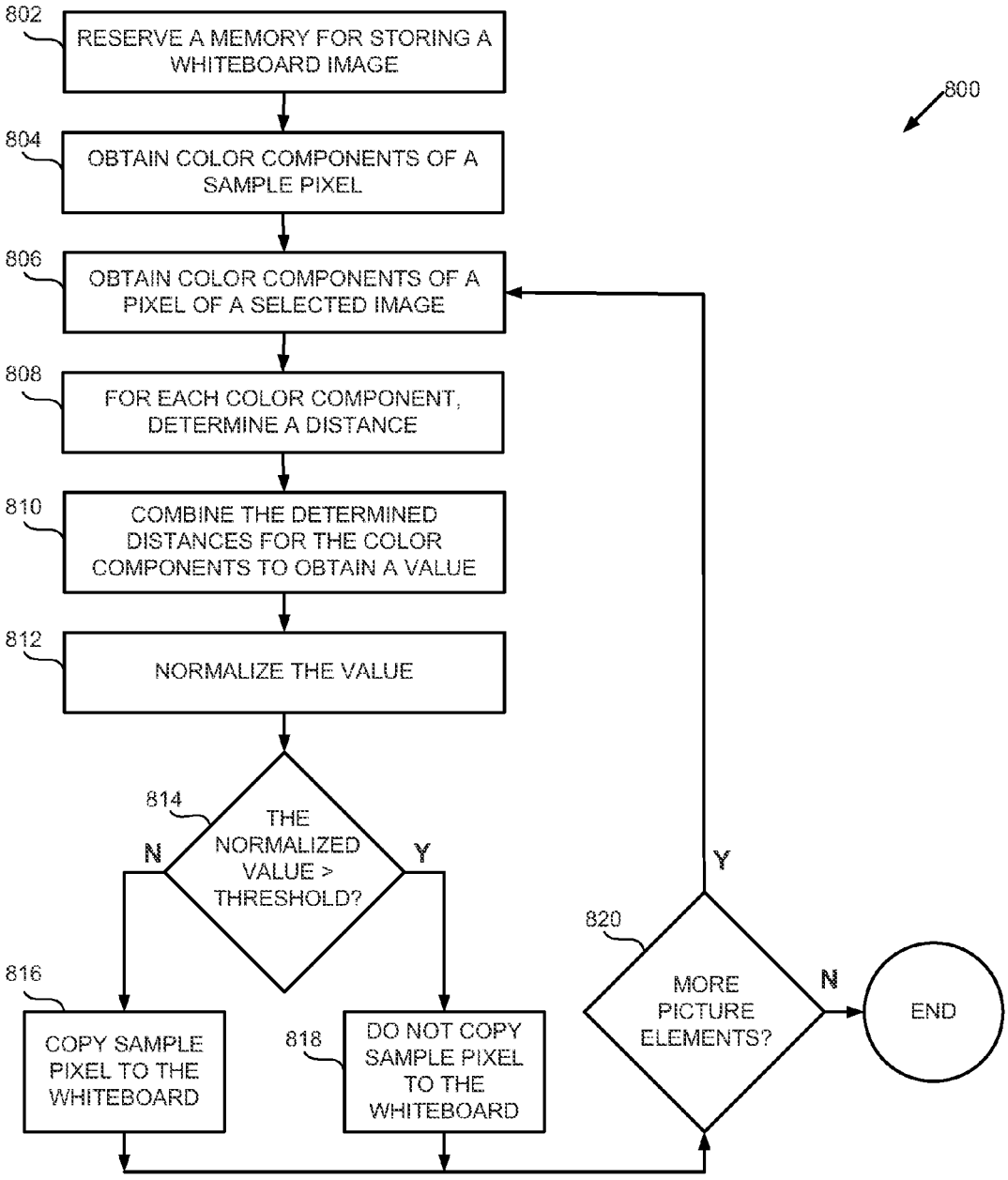
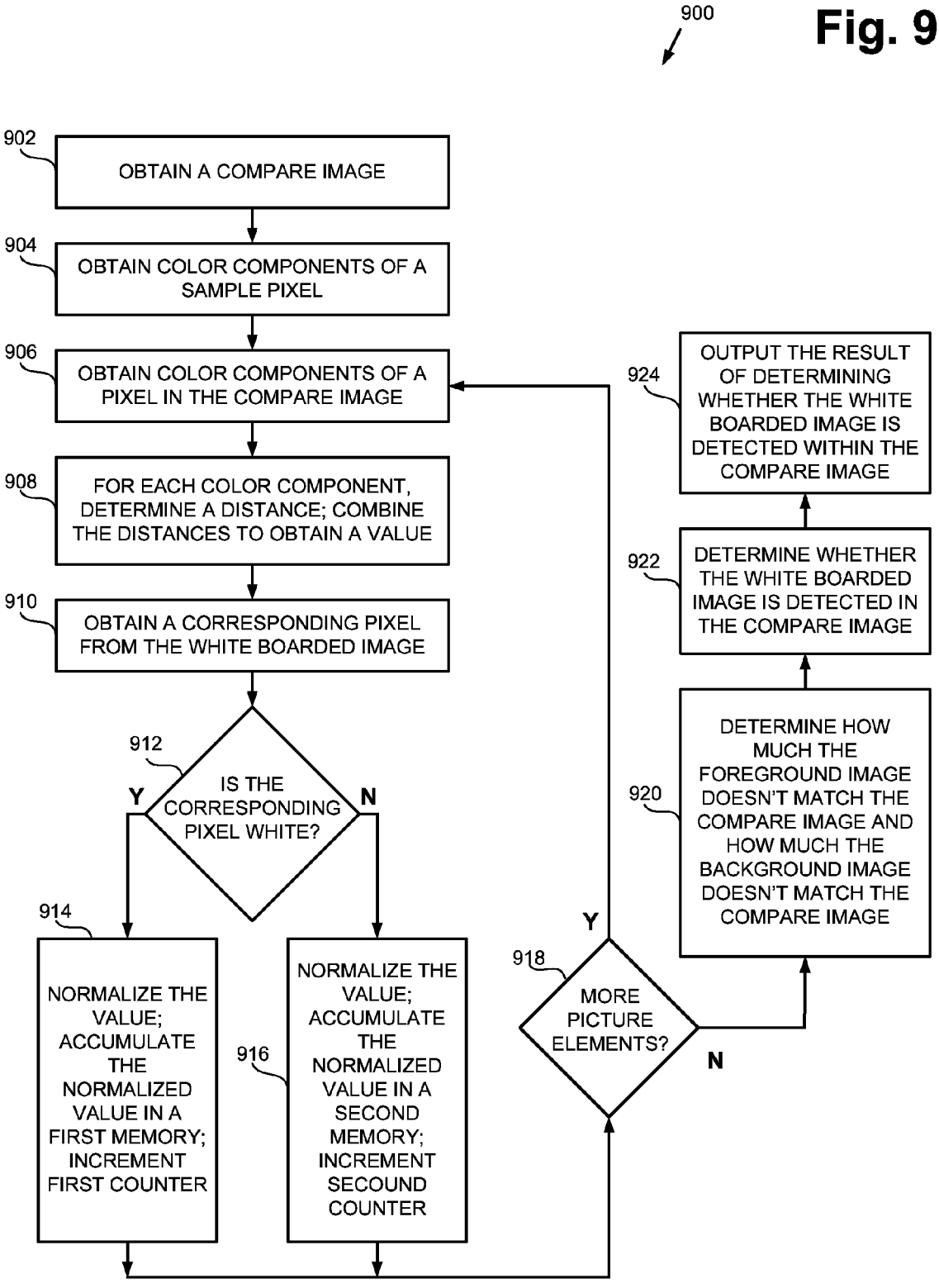

800
802
RESERVE A MEMORY FOR STORING A WHITEBOARD IMAGE
804
OBTAIN COLOR COMPONENTS OF A SAMPLE PIXEL
806
OBTAIN COLOR COMPONENTS OF A PIXEL OF A SELECTED IMAGE
808
FOR EACH COLOR COMPONENT, DETERMINE A DISTANCE
810
COMBINE THE DETERMINED DISTANCES FOR THE COLOR COMPONENTS TO OBTAIN A VALUE
812
NORMALIZE THE VALUE
814
THE NORMALIZED VALUE > THRESHOLD?
N
Y
816
COPY SAMPLE PIXEL TO THE WHITEBOARD
818
DO NOT COPY SAMPLE PIXEL TO THE WHITEBOARD
820
MORE PICTURE ELEMENTS?
Y
N
END

Fig. 9


900
902
OBTAIN A COMPARE IMAGE
904
OBTAIN COLOR COMPONENTS OF A SAMPLE PIXEL
906
OBTAIN COLOR COMPONENTS OF A PIXEL IN THE COMPARE IMAGE
908
FOR EACH COLOR COMPONENT, DETERMINE A DISTANCE; COMBINE THE DISTANCES TO OBTAIN A VALUE
910
OBTAIN A CORRESPONDING PIXEL FROM THE WHITE BOARDED IMAGE
912
IS THE CORRESPONDING PIXEL WHITE?
Y
N
914
NORMALIZE THE VALUE; ACCUMULATE THE NORMALIZED VALUE IN A FIRST MEMORY; INCREMENT FIRST COUNTER
916
NORMALIZE THE VALUE; ACCUMULATE THE NORMALIZED VALUE IN A SECOND MEMORY; INCREMENT SECOUND COUNTER
918
MORE PICTURE ELEMENTS?
Y
N
920
DETERMINE HOW MUCH THE FOREGROUND IMAGE DOESN'T MATCH THE COMPARE IMAGE AND HOW MUCH THE BACKGROUND IMAGE DOESN'T MATCH THE COMPARE IMAGE
922
DETERMINE WHETHER THE WHITE BOARDED IMAGE IS DETECTED IN THE COMPARE IMAGE
924
OUTPUT THE RESULT OF DETERMINING WHETHER THE WHITE BOARDED IMAGE IS DETECTED WITHIN THE COMPARE IMAGE

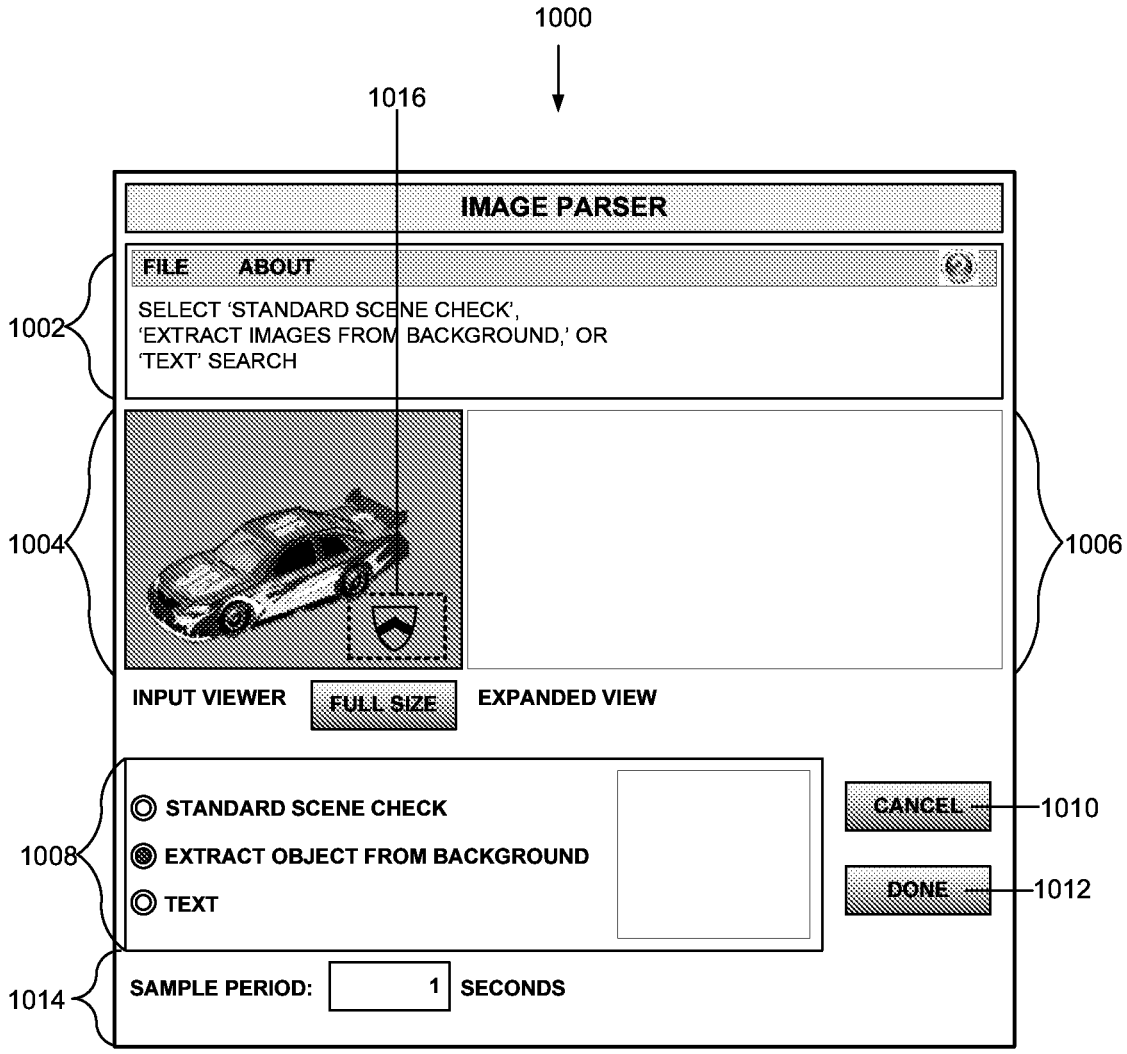

1000
1016
IMAGE PARSER
FILE ABOUT
SELECT 'STANDARD SCENE CHECK',
'EXTRACT IMAGES FROM BACKGROUND,' OR
'TEXT' SEARCH
1002
1004
1006
INPUT VIEWER
FULL SIZE
EXPANDED VIEW
STANDARD SCENE CHECK
EXTRACT OBJECT FROM BACKGROUND
TEXT
1008
CANCEL
1010
DONE
1012
SAMPLE PERIOD:
1
SECONDS
1014

Fig. 10

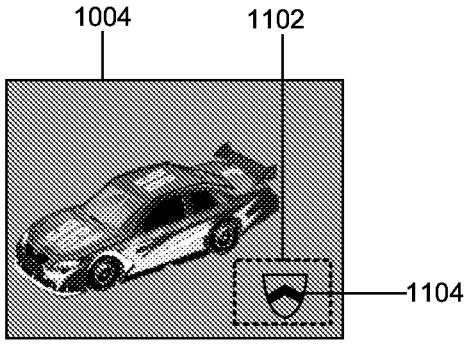


Fig. 11A

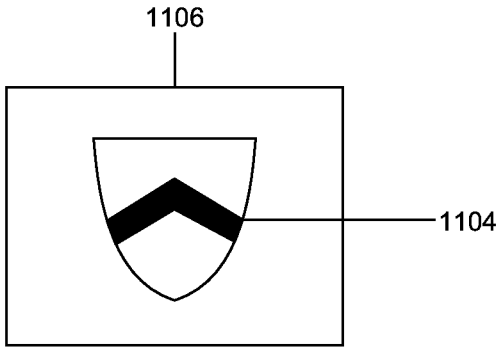


Fig. 11B

SOFT DECISION MAKING PROCESSES FOR ANALYZING IMAGES

BACKGROUND

The quality of video that a set-top box outputs may depend on both an encoded video signal that the set-top box receives from a remote video server and capabilities of the set-top box itself.

When the remote video server encodes a movie for transmission, the signal that the video server generates may depend on the precise starting point in the movie, at which the video server begins to encode the movie. Furthermore, due to noise, starting points for different encoding sessions may be different. Consequently, even from the same movie, the video server may be unable to generate an identical video signal.

When set-top boxes of the same make and model receive an encoded video signal from the same video server, the set-top boxes may generate different output video signals. There are many reasons for the differences. One reason may be that the set-top boxes use different decoding algorithms (e.g., different versions of a decoder). Another reason may be that the set-top boxes produce different amounts of noise in the output video signals. Yet another reason may be that, with respect to hue, color, and saturation, each set-top box may be calibrated differently from other set-top boxes. Yet another reason may be that each set-top box is designed to generate output video whose quality depends on a processing load of the set-top box, and the set-top boxes may be under different processing loads. For example, the set-top boxes may use a decoding algorithm in which rendering a particular frame depends on minute delays in processing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a system in which concepts described herein may be implemented;

FIG. **2**A illustrates exemplary image selection;

FIGS. **2**B and **2**C illustrate exemplary background removal;

FIG. **2**D illustrates quantizing colors and comparing the quantized colors;

FIG. **3** shows an exemplary network in which the system of FIG. **1** may be implemented;

FIG. **4** is a block diagram of an exemplary device of FIG. **3**;

FIG. **5** is a functional block diagram of an exemplary control device of FIG. **3**;

FIG. **6**A is a flow diagram of an exemplary soft decision making process for comparing two images;

FIG. **6**B illustrates an exemplary scheme for representing color components of a pixel;

FIG. **7** is a flow diagram of an exemplary process for obtaining a foreground image;

FIG. **8** is a flow diagram of an exemplary soft decision making process for removing the background of an image;

FIG. **9** is a flow diagram of an exemplary soft decision making process for detecting a foreground image in another image;

FIG. **10** shows a graphical user interface (GUI) window of an exemplary image analyzer of FIG. **5**; and

FIGS. **11**A and **11**B illustrate sampling an image and removing the background from the sampled image.

DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. As used herein, the term "original image" or "sample image" may refer to a portion of an image or an image that is copied or obtained from another image. A sample image may be obtained from different sources, such as a camera, video stream, photograph, picture, etc. The term "compared image" or "compare image" may refer to an image that is compared to the sample image. The term "soft decision" may refer to a process in which the result of a decision is not expressed as one of two possible values (e.g., "yes" or "no," 1 or 0, true or false, etc.) but as a value in a range of real or rational numbers (e.g., 0 to 1, 0 to 100%, [1, 2], etc.). The term "white board" or "whiteboard" may refer to a memory for storing an image whose background is white.

As described herein, soft decision making processes may be used to analyze images. By implementing the soft decision making processes, a device may emulate a human's ability to analyze images better than devices that use a technique known as color quantization.

In one implementation, in analyzing images, the device may compare two images, remove a background from an image to obtain a foreground image, and/or detect the foreground image in other images. Although such a device may have different applications, in the following, the device will be described in context of a system for testing and/or controlling set-top boxes.

FIG. **1** illustrates a system **100** in which concepts described herein may be implemented. As shown, system **100** may include content server **102**, local network **104**, content players **106-1** and **106-2**, and image analyzer **108**. Content server **102** may include logic that transmits an encoded video stream over network **104** to content players **106-1** and **106-2**. Network **104** may include a public (e.g., the Internet) and/or private network. Each of content players **106-1** and **106-2** (e.g., set-top boxes) may decode the encoded video stream from content server **102** and output the decoded video stream.

Image analyzer **108** may receive the decoded video streams from content players **106-1** and/or **106-2**. In addition, image analyzer **108** may analyze or manipulate one or more images in the video streams. Image analyzer **108**, for example, may compare two images, remove a background from an image to obtain a foreground image, and/or detect the foreground image in other images.

FIG. **2**A illustrates selecting an image that is received as part of a decoded video stream at image analyzer **108**. Assume that image analyzer **108** shows the decoded video stream to a user via a window, which is shown as frame **202**. To select a sample image within frame **202**, a user at image analyzer **108** may move a geometrical region **204**, which is shown as a rectangle, within frame **202**. When geometrical region **204** is placed over a portion of image that the user wishes to sample, the user may cause image analyzer **108** to capture or sample the portion of the image (e.g., click a mouse).

FIGS. **2**B and **2**C illustrate removing a background from the selected image. Proceeding with the preceding example, when the user causes image analyzer **108** to sample the image in geometrical region **204**, image analyzer **108** may copy the image from within geometrical region **204** to a whiteboard **206** (FIG. **2**C).

In copying the image from geometrical region **204** to whiteboard **206**, image analyzer **108** may distinguish a foreground image **208** from a background image **210**. More specifically, image analyzer **108** may copy foreground image **208** in geometrical region **204** onto whiteboard **206** as a foreground image **212**, but copy background image **210** as a white image **214**.

Once the selected image is sampled or "white boarded" onto whiteboard **206**, the sampled image may be used to detect similar images within other images. For example, assume that the sampled image in whiteboard **206** image is obtained from a decoded video stream from content player **106-1**. The user at image analyzer **108** may detect the sampled image in a decoded video stream from content player **106-2**.

In some implementations, to manipulate the images as described above or otherwise, image analyzer **108** may quantize colors of the images. However, it is possible for the quantization to introduce undesirable effects.

FIG. **2**D illustrates an example that illustrates quantizing colors and comparing the quantized colors. As shown, FIG. **2**D shows two pixels **220-1** and **220-2**. Assume that pixel **220-1** is from an image in a decoded video stream from content player **106-1**, and that the decoded video stream is generated from an encoded video stream from content server **102**. Also, assume that pixel **220-2** is from a corresponding image in a decoded video stream from content player **106-2**, and that the decoded video stream from content player **106-2** is generated from the same encoded video stream from content server **102**.

Assume that the color of pixel **220-1** in the Red-Green-Blue (RBG) color model is (127, 20, 10); that the color of pixel **220-2** is (129, 10, 20); and quantization converts any color in the range [0, 127] into 0, and any color in the range [128, 255] into 255.

As shown in FIG. **2**D, in accordance with the preceding, image analyzer **108** quantizes the colors of pixels **220-1** and **220-2**, which are (127, 20, 10) and (129, 10, 20) to (0, 0, 0) and (255, 0, 0), respectively. Because the red components of colors (0, 0, 0) and (255, 0, 0) are different, when image analyzer **108** compares the pixels **220-1** and **220-2**, image analyzer **108** concludes that their colors do not match. Although the quantization allows image analyzer **108** to correctly conclude that green and blue components of the colors of pixels **220-1** and **220-2** to match, the quantization also causes image analyzer **108** to generate a false negative in comparing the red components of the colors. This is undesirable even if the images from which pixels **220-1** and **220-2** are obtained are slightly different, assuming that image analyzer **108** is designed to mimic the human ocular system in comparing the images. The difference between **127** and **129** in the red component of the pixels is relatively small, and a human may determine that pixels **220-1** and **220-2** match.

In the following description, instead of quantizing colors, image analyzer **108** (or similar logic) may use soft decision making processes for comparing two images, removing a background of an image to obtain a foreground image (e.g., a white boarded image), and/or detecting the foreground image in other images, etc. As described below in detail, the soft decision making processes may eliminate the undesirable effects that are associated with color quantization, and better emulate a human's ability to match different colors.

FIG. **3** is a block diagram of an exemplary network **300** in which system **100** may be implemented. As shown, network **300** may include a content player device **302** (e.g., a set-top box), remote control **304**, content presentation device **306** (e.g., a television, stereo system, etc.), network **308**, content server device **310**, content storage device **312**, and control device **314**.

Content player device **302** may receive commands from remote control **304** and/or control device **314**, receive content over network **308**, and/or play the content on content presentation device **306**. In some implementations, the content may be obtained from a content distribution system (e.g., a video/audio broadcast system) (not shown) via content-on-demand service (e.g., audio-on-demand or video-on-demand).

Examples of content player device **302** may include a set-top box or a component (e.g., a cable card) that plugs-into a host device (e.g., a digital video recorder, a personal computer, a television, stereo system, etc.) and allows the host device to display multimedia content (e.g., content on digital cable television channels). Although content player device **302** can be implemented as different types of devices (e.g., a set-top-box, computer, digital video disk (DVD) player, cable card, etc.), in the following, content player device **302** is described in terms of a set-top box.

Remote control **304** may include a device for issuing wireless commands to and for controlling electronic devices (e.g., a television, set-top box, stereo system, digital video disc (DVD) player, etc.). In one situation, remote control **304** may be used to obtain content-on-demand (e.g., video-on-demand). In different implementations, in place of remote control **304**, other types of devices (e.g., a wireless keyboard, mouse, handheld device (e.g., cellular phone), etc.) may be used to control the electronic devices.

Content presentation device **306** may include a device for playing media signals and/or signals from content player device **302**. Examples of content presentation device **306** may include a television, one or more speakers and a display, a portable digital assistant (PDA) or a cell phone capable of displaying a received video, etc. In the following paragraphs, content presentation device **306** is assumed to be a television for simplicity and ease of understanding.

Network **308** may include a fiber-optic network (e.g., passive optical networks (PONS)), an ad hoc network, a local area network (LAN), a wide area network (WAN), a wireless LAN, a metropolitan area network (MAN), a cellular network, a public switched telephone network (PSTN), an intranet, the Internet, a satellite-based network, any other network, or a combination of networks. Devices (e.g., content player device **302**, content server device **310**, etc.) that are shown in FIG. **3** may connect to network **308** via wireless or wired communication links. In addition, network **308** may allow any of devices **302-306** and **310-314** to communicate with any other device **302-306** and **310-314**. In some embodiments, devices **302-306** and **310-314** may communicate with each other directly rather than through network **308**.

Content server device **310** may include one or more devices for providing content and/or data. The content and/or data, and/or program may be sent to content player device **302** and/or content presentation device **306**. For example, content server device **310** may provide video-on-demand (VOD), cable programs, etc. to content player device **302**.

Content storage device **312** may include a database of units of content (e.g., a movie, a piece of music, a video clip, etc.). Based on a user request, content server device **310** may retrieve a particular unit of content from content storage device **312** for delivery to a content player device **302**.

Control device **314** may include logic to test and/or control content player device **302**. To test/control content player device **302**, control device **314** may emulate remote control **304**. For example, control device **314** may transmit command signals to content player device **302** over a wired connection to one of infrared ports of content player device **302**.

To test a specific command on content player device **302**, control device **314** may issue the command, cause content player device **302** to forward a decoded video stream to control device **314**, and examine the video stream. Control device **314** may determine whether content player device **302** is operating correctly by analyzing images that are obtained from the video stream.

For example, to determine whether content player device **302** responds correctly to a command for changing the channel, control device **314** may instruct content player device **302** to tune to a specific station that is known to send an encoded video stream of a particular image (e.g., color bars). Control device **314** may then attempt to detect whether the particular image is present in the output video stream of content player device **302**.

Depending on the implementation, network **300** may include additional, fewer, or different devices, or a different arrangement of the devices. For example, network **300** may include a content distribution system (e.g., a video/audio broadcast system), additional control devices, etc. Moreover, one or more devices of network **300** may perform one or more functions of another device of network **300**. For example, content player device **302** and content presentation device **306** may be implemented as a single device. In another example, data or information stored on content storage device **312** may be stored on multiple devices.

In addition, although control device **314** is described as implementing soft decision making processes for image analysis/manipulation, depending on the implementation, a different type of network, system, or device may implement the soft decision making processes. For example, in one implementation, a device and/or program for analyzing or manipulating photographs may implement the soft decision making processes for comparing one photograph to another, for example, to detect copyright violations.

FIG. **4** is a block diagram of an exemplary network device **400**, which may correspond to content player device **302**, content presentation device **306**, content server device **310**, content storage device **312**, and/or control device **314**. As shown, network device **400** may include a processor **402**, a memory **404**, input/output components **406**, a network interface **408**, and a communication path **410**. In different implementations, network device **400** may include additional, fewer, or different components than the ones illustrated in FIG. **4**. For example, network device **400** may include line interfaces, such as interfaces for receiving and forwarding data.

Processor **402** may include a processor, a microprocessor, an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), and/or other processing logic capable of controlling network device **400**. Memory **404** may include static memory, such as read only memory (ROM), and/or dynamic memory, such as random access memory (RAM), or onboard cache, for storing data and machine-readable instructions. Memory **404** may also include storage devices, such as a floppy disk, CD ROM, CD read/write (R/W) disc, and/or flash memory, as well as other types of storage devices.

Input/output components **406** may include a display screen, a keyboard, a mouse, a speaker, a microphone, a Digital Video Disk (DVD) writer, a DVD reader, Universal Serial Bus (USB) lines, and/or other types of components for converting physical events or phenomena to and/or from digital signals that pertain to network device **400**.

Network interface **408** may include any transceiver-like mechanism that enables network device **400** to communicate with other devices and/or systems. For example, network interface **408** may include mechanisms for communicating via a network, such as the Internet, a terrestrial wireless network (e.g., a WLAN), a satellite-based network, etc. Additionally or alternatively, network interface **408** may include a modem, an Ethernet interface to a LAN, and/or an interface/connection for connecting network device **400** to other devices (e.g., a Bluetooth interface).

Communication path **410** may provide an interface through which components of network device **300** can communicate with one another.

FIG. **5** is a functional block diagram of control device **314**. As shown, control device **314** may include a controller **502** and image analyzer **504**. Although not illustrated, control device **314** may include additional components, such as components illustrated in network device **400**, an operating system (e.g., Linux, Windows, etc.), an application, a component for issuing remote commands to content player device **302**, etc.

Controller **502** may schedule and/or perform transmission of commands for controlling content player device **302** (e.g., a command to change the channel). In addition, controller **502** may verify whether a transmitted command has failed. A command may fail for several reasons, such as, for example, the command has not been sent correctly (e.g., due to a failure of an infrared transmitter); an infrared input or processing at content player device **302** may not be operating correctly; content player device **302** may be unable to output a decoded video stream; etc.

Controller **502** may perform the verification of the command by obtaining an output video stream of content player device **302** and by using image analyzer **504** to analyze images that are in the video stream. For example, controller **502** may detect, via image analyzer **504**, a specific image (e.g., embedded station-identification text, channel number, or a specific image overlaying content, color bars for a local channel, etc.) in the video stream, to verify that the command resulted in correctly changing the channel. In another example, controller **502** may send a separate command that will generate a video activity (e.g., game show, soap opera, etc.) at a tuned channel, and may identify anticipated images at the tuned channel. In yet another example, controller **502** may verify tuned channel/program from a video menu, by requesting additional information by, for example, issuing an information-requesting command or selecting an item on a menu guide.

In verifying the success of commands, controller **502** may avoid pitfalls that are associated with an approach that uses program schedules. For example, one approach may be to obtain a schedule of channel programs. Based on the schedule, controller **502** may attempt to determine what scenes or image should appear in the video stream when a particular command is executed at content player device **302**, and, after the execution of the command, may attempt to detect the scenes at the video output of content player device **302**. This approach may be problematic, because the schedule and/or channels that are assigned to particular stations may frequently and unpredictably change.

Image analyzer **504** may obtain a decoded video stream from content player device **302**, analyze the decoded video stream, and provide the result of the analysis to controller **502** and/or a user. For example, image analyzer **504** may compare one image to another image, select or sample an image in a video stream, remove a background of the image to obtain a foreground image, detect the foreground image in other images, etc. In analyzing these images, image analyzer **504** may use soft decision making processes.

FIG. **6**A is a flow diagram of an exemplary soft decision making process **600** for comparing two images. Assume that controller **502** has caused image analyzer **504** to obtain two images, a first image and a second image, from a video stream(s). In addition, assume that two arrays or vectors, A and B, represent the first image and the second image, respectively, and that colors of i^{th} pixel of the first image and the second image may be written as A(i) and B(i), respectively,

where i is a non-negative integer. Process **600** may begin with image analyzer **504** obtaining a first color of a first pixel from the first image and a second color of a second pixel from the second image (block **602**). Image analyzer **504** may obtain A(i) and B(i) from, for example, the images stored in a memory (e.g., memory **404**).

Image analyzer may determine whether the first color is the same as the second color (block **604**). For example, in one implementation, image analyzer **504** may compare if A(i) is equal to B(i) to determine if the colors are the same. If the first color is the same as the second color (block **604**—YES), process **600** may proceed to block **616** (to be described below).

Otherwise (block **604**—NO), image analyzer **504** may obtain color components of the first color and color components of the second color (block **606**). Depending on the implementation, a color (e.g., A(i)) may represent color components (e.g., red, green, and blue in RGB representation) in accordance with a specific encoding scheme.

FIG. **6**B illustrates one exemplary scheme for representing the color components of A(i). As shown, in the scheme, color components of A(i) include red R_A, green G_A, and blue B_A. In addition, the most significant 8 bits, the second most significant 8 bits, and the least significant 8 bits of A(i) represent R_A, G_A, and B_A, respectively. In this example, image analyzer **504** may obtain B_A by masking out the upper 16 bits of A(i), G_A by shifting A(i) eight bits to the right and masking out the upper 16 bits, and R_A by shifting A(i) 16 bits to the right and masking out the upper 16 bits. In a different implementation, image analyzer **504** may use other computational operations that are equivalent to bitwise shifting and/or masking bits (e.g., dividing or multiplying by 2, computing modulo (e.g., 10 modulo 256) of a result of the shifting, etc.) to obtain the color components. Image analyzer **504** may obtain the color components of B(i) (e.g., R_B, B_B, and G_B) similarly.

For each color component of A(i) and B(i), image analyzer **504** may compute a distance (block **608**). For example, assume that a distance D between one color component and another color component is given by the absolute value of a numerical difference of the color components. Then, image analyzer **504** may compute a distance for red, D_R=ABS(R_A−R_B), for green, D_G=ABS(G_A−G_B), and for blue, D_B=ABS(B_A−B_B), where ABS(.) represents the absolute value of a quantity in the parenthesis. Depending on the implementation, image analyzer **504** may use a different metric for determining the distance between the color components. For example, in one implementation, image analyzer **504** may determine the distance by computing a numerical difference of the color components without computing absolute values.

Image analyzer **504** may combine the distances between the colors components of the first color and the second color to obtain a value (block **610**). Continuing with the above example, assume that V represents the value. In one implementation, image analyzer **504** may determine V by adding the differences determined at block **608**. Therefore, V=D_R+D_G+D_B. In a different implementation, image analyzer **504** may combine the distances in accordance with a different scheme.

Image analyzer **504** may normalize the value (block **612**). In one implementation, for example, V may be normalized by multiplying V with a pre-determined coefficient C_f to obtain a normalized value, V_N. In some implementations, if V_N>1.0, image analyzer **504** may reset or cap V_N such that V_N=1.0.

Image analyzer **504** may accumulate the normalized value (block **614**). In one implementation, image analyzer **504** may accumulate the normalized value by adding the value to an accumulated value obtained in a prior performance of blocks **602-616**. For example, assume that V_N in a first iteration of blocks **602-614** is 0.2 and is 0.3 in a second iteration. The accumulated value is 0.2+0.3=0.5. The accumulated value may increase as image analyzer **504** iterates through blocks **602-614**.

Image analyzer **504** may determine whether there are additional pixels for further processing (block **616**). If there are additional pixels (block **616**—YES), process **600** may return to block **602**.

Otherwise, image analyzer **504** may determine a percent difference between the first image and the second image (block **618**). In one implementation, image analyzer **504** may determine the percent difference by dividing the accumulated value by the total number of pixels. For example, assuming that T is the total number of pixels, A_V is the accumulated value, and P is the percent difference, image analyzer **504** may determine P in accordance with P=A_V·100/T.

In image analysis or processing, image analyzer **504** may remove a background from a sample image to obtain a foreground image. Image analyzer **504** may use the resulting foreground image, herein termed "white boarded image" or "whiteboard image," for further image analysis (e.g., detecting the presence of the foreground image in other images).

FIG. **7** is a flow diagram of an exemplary process for obtaining a foreground image. Assume that image analyzer **504** has captured a frame of a decoded video stream, and shows the frame (e.g., frame **202**) to a user via its graphical user interface (GUI). Process **700** may begin with a selection of a region or area in the frame (block **702**). For example, as illustrated in FIG. **2**A, a user may indicate, via movable geometrical region **204**, an area that the user wants to capture as a sample image. In response, image analyzer **504** may select the area (e.g., store the coordinates of a rectangle encompassing the area).

Image analyzer **504** may obtain a sample pixel (block **704**). In one implementation, the user may move a mouse cursor over frame **202** until the mouse cursor is over a pixel that is representative of the color of the foreground image, and click the mouse to instruct image analyzer **504** to sample the pixel. In another implementation, image analyzer **504** may sample a pixel that is at the center of the selected region (see block **702**).

Using the sample pixel, image analyzer **504** may remove the background of the image in the selected region in accordance with a soft decision making process (block **706**).

FIG. **8** is a flow diagram of an exemplary soft decision making process for removing the background of an image. It is assumed that an image has been selected and that a sample pixel has been obtained, as described above for blocks **702** and **704**. Process **800** may begin at block **802**, where image analyzer **504** reserves a memory for storing a white boarded image (block **802**). For the example below, assume that W(i) represents either the i^{th} pixel of the white boarded image, or a portion of the reserved memory that stores the pixel.

Image analyzer **504** may obtain color components of the sample pixel (see block **704**) (block **804**). Assume that X represents the sample pixel and encodes the color of the sample pixel in the manner A(i) encodes a color (see FIG. **6**B). In such a case, image analyzer **504** may obtain the color components, R_X, G_X, and B_X of X in a manner similar to that for obtaining the color components of A(i).

Image analyzer **504** may obtain color components of a pixel of the selected image (block **806**). Assume that S(i) represents i^{th} pixel of the selected image and encodes the color components as A(i) encodes a color. In such a case,

image analyzer **504** may obtain the color components, R_S, G_S, and B_S of S(i) in the same manner that color components are obtained for A(i).

For each color component, image analyzer **504** may determine a distance (block **808**). For example, using the same distance metric described at block **608**, image analyzer **504** may compute distance for the red component D_R as $ABS(R_X-R_S)$, a distance for the green component D_G as $ABS(G_X-G_S)$, and a distance for the blue component D_B as $ABS(B_X-B_S)$.

Image analyzer **504** may combine the determined distances to obtain a value (block **810**). Continuing with the preceding example, and assuming V is the value, image analyzer **504** may compute $V=D_R+D_G+D_B$.

Image analyzer **504** may normalize the value (block **812**). As discussed above for block **612**, image analyzer **504** may multiply the value V by some predetermined coefficient, Y_F, to obtain a normalized value, $V \cdot Y_F$.

Image analyzer **504** may determine whether the normalized value is greater than a particular threshold (e.g., a threshold of 1) (block **814**). For example, image analyzer may determine whether $V \cdot Y_F > 1$. If the normalized value is greater than the threshold (block **814**—YES), image analyzer **504** may determine that the color of the sample X does not match the color of S(i) (block **818**). In such a case, image analyzer **504** may store a value representing the white color at a corresponding location in the memory reserved for the whiteboard. That is, assuming that W(i) stores the i^{th} pixel of the white boarded image and H represents the white color, image analyzer **504** may store H at W(i). That is, W(i)=H.

If the normalized value is not greater than the threshold, image analyzer **504** may determine that the color of the sample pixel X matches the color of S(i) (block **816**). In such a case, image analyzer **504** may copy the pixel of the sample image in the white board. That is, W(i)=S(i).

If the normalized value is not greater than the threshold, image analyzer **504** may determine that the color of the sample pixel X matches the color of S(i). In such a case, image analyzer **504** may copy the pixel of the sample image in the white board. That is, W(i)=S(i).

At block **820**, image analyzer **504** may determine if there are more pixels to be processed (block **820**). If there are more pixels, process **800** may loop back to block **806**. Otherwise, process **800** may terminate. At the end of process **800**, a white boarded image, which is the foreground image of the sample image, is stored in the reserved memory (see block **802**). If the white boarded image is not satisfactory for the user at image analyzer **504**, the user (and therefore, image analyzer **504**) may repeat process **700** or **800** to obtain a new white boarded image.

In analyzing images, image analyzer **504** may use the sampled pixel (see block **804**) and the white boarded image obtained at process **800**. For example, image analyzer **504** may detect the white boarded image (e.g., the foreground image) in another image.

FIG. **9** is a flow diagram of an exemplary soft decision making process for detecting/extracting a white boarded image in another image. Assume that image analyzer **504** has obtained a white boarded image (e.g., a foreground image) from a specific area within a frame (e.g., frame **202**) and a sample pixel.

Image analyzer **504** may obtain a compare image (block **902**). For example, image analyzer **504** may obtain the compare image by first obtaining a compare frame in a video stream. Once the compare frame is obtained, image analyzer **504** may copy the image in an area at the same location in the compare frame as the white boarded image in the frame from which the sample image is obtained. For example, assume that the white boarded image is rectangular, and that the X-Y screen coordinates of the upper left corner of the white boarded image within the sample image (e.g., image from which the white boarded image is created) is (10,10). In such an instance, image analyzer **504** may obtain the compare image from the compare frame at the same coordinates (10, 10).

Image analyzer **504** may obtain the color components of a sample pixel (block **904**). Image analyzer **504** may obtain the color components in a manner similar to that described for block **804**. In one implementation, instead of obtaining the color components, image analyzer **504** may determine the average foreground color of the white boarded image, and obtain the color components of the average foreground color.

Image analyzer **504** may obtain the color components of a pixel in the compare image (block **906**). Image analyzer **504**, for each color component, may determine a distance between the pixel in the compare image and the sample pixel (block **908**), and combine the distances of the color components to obtain a value V, and normalize the value (e.g., by multiplying by a constant) (block **908**).

Image analyzer **504** may obtain, from the white boarded image, a pixel whose location corresponds to that of the pixel from the compare image (block **910**). In one implementation, the location may be determined based on the X-Y coordinates of the pixel in the compare image.

At block **912**, image analyzer **504** may determine whether the corresponding pixel in the whiteboard is white (block **912**). For example, image analyzer **504** may test whether the sum of the red, green, and blue components of the pixel is equal to 765 (e.g., R+G+B=765). In another example, image analyzer **504** may test whether all of the bits of the pixel are 1's.

If the corresponding pixel is white (block **912**—YES), image analyzer **504** may determine that the pixel in the compare image is part of the background, and compute parameters for determining a dissimilarity between the background color of the compare image and the foreground color of the sample image (e.g., the color of the sample pixel). Such parameters measure the likelihood of the background of the compare image being misinterpreted as the foreground of the sample image (e.g., a likelihood of providing a false positive).

For example, assuming that the value obtained at block **908** is represented by V, image analyzer **504** may multiply V by a coefficient C (e.g., 0.007) to obtain a normalized value V_N (block **914**). V_N may be capped at some predetermined constant (e.g., 1.0) (see the above description of block **612**). In addition, at block **914**, image analyzer **504** may accumulate normalized values V_N in a first memory (e.g., a piece of memory in memory **404**) to obtain accumulated value A_B, and increment a first counter for tracking the number of times (n) block **914** is performed (block **914**). n is also equal to the number of pixels in the background of the compare image. The accumulated value A_B and n may increase as image analyzer **504** iterates through blocks **906-914** and **918**.

If the corresponding pixel is not white (block **912**—NO), image analyzer **504** may determine that the pixel in the compare image is part of the foreground, and compute parameters for determining a dissimilarity between the foreground color of the compare image to the foreground color of the white boarded image (e.g., the color of the sample pixel). Continuing with the preceding example, image analyzer **504** may multiply a coefficient U (e.g., 0.002) by V to obtained a normalized value V_M (block **916**). Coefficient U may be different from coefficient C referenced above.

V_M, like V_N, may be capped at some predetermined constant (e.g., 1.0). In addition, at block **916**, image analyzer **504**

may accumulate normalized values V_M in a second memory to obtain accumulated value A_F, and increment a second counter (m) for tracking the number of times block **916** is performed (block **916**). m is also equal to the number of pixels that are in the foreground of the compare image.

At block **918**, image analyzer **504** may determine whether there are additional pixels for further processing (block **918**). If there are additional pixels (block **918**—YES), process **900** may loop back to block **906**. Otherwise, image analyzer **504** may determine how much each of the foreground and background images does not match the compare image (block **920**). Continuing with the example, image analyzer **504** may calculate % foreground mismatch (M_F) by calculating $100 \cdot A_F/m$, and % background mismatch (M_B) by calculating $100 \cdot A_B/n$.

Image analyzer **504** may determine whether the white boarded image is detected in the compare image (block **922**). In some instances, image analyzer **504** may determine that the white boarded image is detected in the compare image solely based on the foreground mismatch. In other instances, image analyzer **504** may determine that the white boarded image is detected in the compare image if either the background mismatch is greater than a predetermined background threshold (T_B) or the foreground mismatch is less than a predetermined foreground threshold (T_F). By determining $M_B > T_B$ and/or $M_F < T_F$, image analyzer **504** may reduce the possibility of obtaining a false positive detection of the white boarded image in the compare image. For example, image analyzer **504** may conclude that the compare image does not include the white boarded image if either $M_B \leq T_B$ or $M_F \geq T_F$.

Image analyzer **504** may output the result of determining whether the white boarded image is detected within the compare image (block **924**). Put differently, image analyzer **504** may output the result of performing block **922**, for example, via a GUI, email, web page, etc.

FIG. **10** illustrates a GUI window **1000** of image analyzer **504**. As shown, GUI window **1000** may include an instruction pane **1002**, video frame pane **1004**, expanded view pane **1006**, option pane **1008**, cancel button **1010**, done button **1012**, and sampling pane **1014**. Depending on the implementation, GUI window **1000** may include additional, fewer, or different components than those illustrated in FIG. **10**. For example, when image analyzer **504** is implemented as part of a photograph analysis application, GUI window **1000** may include a pane for selecting a different album, edit menus for annotating, cropping, resizing, rotating, and/or performing other types of image operations.

Instruction pane **1002** may list or explain the type of analysis or operation that a user may perform. For example, in FIG. **10**, instruction pane **1002** shows that the user may select a "standard scene check" for detecting a sampled image within a video stream, "extract images from background" for sampling an image and removing a background from the sampled image (e.g., white boarding the image), or "text search" for identifying text within a region (e.g., geometrical region **204**).

Video frame pane **1004** may show a video stream. Although not illustrated in FIG. **10**, window **1000** may provide GUI components for controlling the video stream (e.g., pause, resume, etc.). Expanded view pane **1006** may show, when activated, an enlarged portion of video frame pane **1004**. Option pane **1008** may provide GUI components that correspond to each of the options that are described in instruction pane **1002**. As shown, the user may select a radio button that corresponds to one of "standard scene check," "extract object from background," and "text."

Cancel button **1010** and done button **1012**, when activated, may cause image analyzer **504** to stop performing the analysis or operation selected via option pane **1008**. Cancel button **1010**, however, may be activated when image analyzer **504** is performing an analysis. Done button **1012** may be activated when image analyzer **504** has already compared a sample image to a compare image, and is continuing to compare the sample image to additional images in a video stream. In such a situation, when a user presses done button **1012**, image analyzer **504** may stop comparing the images and save parameters that are associated with the compared images (e.g., percent match). Sampling pane **1014** may include an input box, in which the user can type or select a time interval for periodically sampling a frame from a video stream.

As further shown in FIG. **10**, frame pane **1004** may include rectangular sampling area **1016** (e.g., geometrical region **204**). Via the GUI, the user may move sampling area **1016** within frame plane **1004**, to indicate an area of image that is to be sampled.

FIGS. **11**A and **11**B illustrate removing a background from the image in frame pane **1004**. As shown in FIG. **11**A, when sampling area **1102** is over a desired portion of the framed image, such as a chevron insignia **1104**, the user may activate sampling area **1102** (e.g., click on a mouse) to sample the desired portion. Upon detecting the user's action, image analyzer **504** may remove the background of the image in sampling area **1102** to obtain a white boarded image of chevron insignia **1104** in accordance with process **800**.

FIG. **11**B shows a whiteboard **1106**. As shown, whiteboard **1106** includes chevron insignia **1104**. At later times, the user at image analyzer **504** may compare the white boarded image in whiteboard **1106** to images in frames of different video streams. When image analyzer **504** detects a frame that includes chevron insignia **1104**, image analyzer **504** may alert the user of the detection.

In the foregoing description, image analyzer **504** (or similar logic) may use soft decision making processes for analyzing/manipulating images. For example, image analyzer **504** may compare images, remove a background of an image to obtain a white boarded image, and/or compare the white boarded image to other images. By using the soft decision making processes, image analyzer **504** may eliminate undesirable effects that are associated with color quantization.

The foregoing description of implementations provides illustration, but is not intended to be exhaustive or to limit the implementations to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of the teachings. For example, in different implementations, a device may use the soft decision making processes to detect an object, event, or a motion in a video stream (e.g., by detecting an image in the video stream or an image associated with the event in the video stream), In yet another implementation, a device may use the soft decision making processes to test a set-top box controlling command (e.g., by detecting an image at the output of the set-top box).

In addition, while series of blocks have been described with regard to exemplary processes illustrated in FIGS. **6-9**, the order of the blocks may be modified in other implementations. In addition, non-dependent blocks may represent acts that can be performed in parallel to other blocks.

It will be apparent that aspects described herein may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in the figures. The actual software code or specialized control hardware used to implement aspects does not limit the invention. Thus, the operation and behavior of the aspects were described without reference to the specific software code—it being

understood that software and control hardware can be designed to implement the aspects based on the description herein.

Further, certain portions of the implementations have been described as "logic" that performs one or more functions. This logic may include hardware, such as a processor, a microprocessor, an application specific integrated circuit, or a field programmable gate array, software, or a combination of hardware and software.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the invention. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

No element, act, or instruction used in the present application should be construed as critical or essential to the implementations described herein unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A non-transitory computer-readable medium including computer-executable instructions, the computer-executable instructions comprising:

instructions for obtaining, for each pixel of a plurality of pixels, a normalized value, the instructions including instructions for:

obtaining a first color from one of the plurality of pixels,

extracting color components from the first color and a second color,

determining, for each of the color components, a distance between the first color and the second color, and

combining the distances for the color components to obtain the normalized value for each pixel, wherein the normalized value equals the combined distances multiplied by a number;

instructions for obtaining a sum, of the normalized values for the plurality of pixels, that is compared to a threshold, wherein a first image includes the plurality of pixels, wherein a result of the comparison indicates whether the first image matches a second image that includes the second color;

instructions for determining whether one of the pixels that includes the first color is to be copied to a whiteboard, and displaying the whiteboard via a graphical user interface; and

instructions for determining whether a third image that includes the pixels is detected as a foreground image of a fourth image that includes the second color and displaying a result of the determination via a graphical user interface.

2. The non-transitory computer-readable medium of claim **1**, further comprising instructions for:

receiving a selection of an area that includes the first image.

3. The non-transitory computer-readable medium of claim **1**, wherein the instructions for combining the distances include instructions for:

multiplying a sum of the distances by a coefficient; and

when a result of multiplying the sum by the coefficient exceeds a constant, setting the value to be equal to the constant.

4. The non-transitory computer-readable medium of claim **1**, wherein the instructions for determining, for each of the color components, a distance include instructions for at least one of:

computing a difference between a color component of the first color and a corresponding color component of the second color; or

computing an absolute value of the difference.

5. The non-transitory computer-readable medium of claim **1**, wherein the instructions for combining the distances include instructions for:

adding the distances.

6. The non-transitory computer-readable medium of claim **1**, wherein the instructions for determining whether the third image is detected as a foreground image of the fourth image include at least one of:

instructions for determining how much of the third image matches a background image of the fourth image; or

instructions for determining how much of the third image does not match the foreground image of the fourth image.

7. The non-transitory computer-readable medium of claim **1**, wherein the fourth image includes a whiteboard image.

8. The non-transitory computer-readable medium of claim **1**, wherein the first image includes a portion of a frame of a video stream.

9. The non-transitory computer-readable medium of claim **1**, further comprising at least one of:

instructions for detecting a motion in a video stream that includes one of the second image or the foreground image of the fourth image;

instructions for recognizing images of an object in a video stream, the images of the object including one of the second image or the foreground image of the fourth image;

instructions for detecting an event in a video stream, the event being associated with the second image or the foreground image of the fourth image; or

instructions for verifying a command that causes a device to output the second image or the foreground image of the fourth image.

10. The non-transitory computer-readable medium of claim **1**, wherein the second color includes:

an average color of an image in the whiteboard.

11. The non-transitory computer-readable medium of claim **1**, wherein the color components include:

red, green, and blue.

12. A method comprising:

calculating, for each of a plurality of pixels in a frame of a video stream, a normalized value, including:

obtaining a first color from the pixel and a second color,

obtaining color components of the first color and the second color,

for each of the color components, determining a distance between the color component of the first color and the color component of the second color, and

adding the distances of the color components to obtain the normalized value for the pixel, wherein the normalized value is equal to the added distances multiplied by a number;

computing an accumulation of the normalized values obtained for each pixel in a first image within the frame;

comparing the accumulation to a threshold to determine whether the first image matches a second image that includes the second color;

displaying a result of determining whether the first image matches the second image via a graphical user interface (GUI);

determining whether one pixel, among the plurality of pixels, that includes the first color is to be copied to a whiteboard, and displaying the whiteboard via the GUI; and

determining whether a third image that includes the plurality of pixels is detected as a foreground image of a fourth image that includes the second color and displaying a result of the determination via the GUI.

13. The method of claim **12**, wherein obtaining color components includes:

dividing a number representing the first color by a constant; and

obtaining a modulo of a result of the division.

14. The method of claim **12**, wherein determining a distance includes:

calculating a difference between the component of the first color and the component of the second color.

15. The method of claim **12**, wherein accumulating the normalized value includes:

a value obtained by multiplying the accumulation by a constant.

16. The method of claim **12**, further comprising:

selecting the first image in the frame via the GUI.

17. A device comprising:

a communication interface to receive a video stream from a remote device; and

a processor to:

obtain an image from the video stream,

obtain a reference color from a user via a graphical user interface,

for each pixel in the image, for each of a plurality of color components, determine a difference between the color component of the pixel and the color component of the reference color, total the differences to obtain a distance, and normalize the distance for the pixel,

add the normalized distances of the pixels to obtain a sum,

compare the sum to a threshold to determine whether the image matches a reference image that includes the reference color or to determine whether the image is a foreground image of a reference image that includes the reference color,

display a result of comparing the sum to the threshold,

determine whether one pixel, among pixels of the image, that includes a first color having the plurality of color components is to be copied to a whiteboard, and display the whiteboard via a graphical user interface (GUI); and

determine whether a third image that includes pixels of the image is detected as a foreground image of a fourth image that includes the reference color and display a result of the determination via the GUI.

18. The device of claim **17**, further comprising:

an infrared output port to issue commands to the remote device.

19. The device of claim **17**, wherein the remote device includes:

a set-top box, a digital television that includes a plug-in cable card, or a computer.

20. The device of claim **17**, wherein the reference image includes a white boarded image.

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